FMVSS Head Crash Target Point Bp2 FEA Simulation Using B Pillar Trim

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Abstract- The major area where most of the automobile industries are concentrated nowadays is protection of passengers during the crash. Most of the passengers will suffer from head injury during crash, when head of the passenger will impact the parts of the car such as in rollover or side impact the head of the passenger will be impacted with the pillars of the vehicle. The sports utility vehicles have more tendencies to rollover compared to other passenger vehicles as they will be having higher center of gravity.

In this paper we describe the CAE technique for the simulation of interior head impact test as per Federal Motor Vehicle Safety Standard (FMVSS 201). Where FMVSS 201 is the standards for occupant protection for interior impacts. Here in this paper as we are concentrated on head impact of passenger we follow FMVSS 201U standards. This paper describes how we carried out iteration to meet FMVSS standard to reduce Head Impact Criteria value below 1000.

I. INTRODUCTION

Head injury is the most frequent type of injury experienced by seriously injured passengers. Vehicle crash worthiness and occupant safety are the major area of concentration where all automobile industries are considered nowadays.

The test procedure FMVSS 201 was established to increase protection from head injury in crashes. Depending upon the vehicle type there are 23 target points to consider.

FMVSS 201U regulations

- The FMVSS has set the guidelines to be followed on which the safety of the occupant in the passenger vehicle has to be evaluated.
- As per FMVSS if the value of head impact criteria is more than 1000 it will cause fatality and vehicle is considered as unsafe.

Head Injury Criteria

- Head injury criteria are a measure of likelihood of head injury due to an impact.
- Normally the variable is derived from the acceleration vs time history of an accelerometer mounted at the center of gravity of dummy head. When the dummy is experiencing crash forces.

Head Injury Criterion Equation with Abbreviations

$$HIC = \max_{t_1,t_2} \left\{ \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t)dt \right]^{2.5} (t_2 - t_1) \right\}$$

Where t1 and t2 are the initial and final times (in seconds) of the interval during which HIC attains a maximum value and acceleration is measured in g's. Note also the maximum time duration of HIC, t2 - t1, is limited to a specific value, usually 15 ms. HIC (d) =0.75446(Free Motion Headform HIC) + 166.4

Free motion Head Form

- Free motion headform is the Hybrid III dummy model with the 50% human head.
- This is the universal dummy used for the physical testing of occupant for interior impact injury evaluation.
- The corresponding calibrated FE model of FMH is available which can be used in FEM simulation.

FEM

- FEM is the numerical method of solving any engineering problem with approximate and assumptions made.
- FEM reduces DOF from Infinite to finite by discretizing ie. Meshing.
- There are 3 steps involved in commercial softwares.
- Preprocessing: once we receive cad data meshing is carried out using softwares like hypermesh and boundary conditions are applied.
- Processing: In this step we submit the run using softwares like LS dyna which will carry out matrix, formulation, inversion, multiplication and solution for unknowns like displacement, stress, strain.
- Post Processing: In this method we view results, verification, conclusion and will think about steps to further improvement.

II. EXPERIMENTAL WORK

By using the available cad model simulation has been carried out.

CAD Model Overview

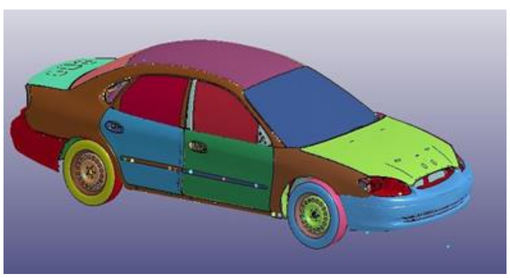

Figure 01

As we are concentrated on BP2 target point of the B pillar the meshing has been carried out only to required area and deck as been set accordingly.

Figure 02

Meshing of dummy and B Pillar has been carried out as per the instruction from the simulation experts.

- Meshing: Types of meshing carried out are 2d shell mesh, 3d solid mesh and 1d mesh.

Numbering of Parts are done as mentioned below,
Dummy: 1-8
Bpillar:50000001-50000058

- Materials: The type of materials used in this simulation are listed below
- Rigid- Mat20
- Deformable – Mat24
- Null- Mat09
- Elastic- Mat01
- Weld- Mat100
- Rubber- Mat07

- Vehicle Connections

- Nodal Rigid Body to Connect Deformable to Deformable materials
- Rigid Bodies to Connect Rigid to Rigid materials
- Extra Node to Connect Rigid to Deformable materials
- Spot-weld to Connect two sheet metal components
- Revolute Joint to achieve the revolutionary motion
- Spherical Joint to achieve the Spherical motion
- Adhesives for gluing the plastic components
- Beam Weld to connect Sheet metal components

using 1D elements

- Initial Velocity:

15MPH i.e. 6.7mm/ms a per USNCAP (United State New Car Assessment Program Regulation)

Units Used:

- Mass in Kg
- Time in ms
- Distance in mm
- Stress in GPA

- Free Motion Headform Positioning:

The FMH is made positioned against the Vehicle B Pillar A-Surface using USNCAP FMVSS201U Regulation.

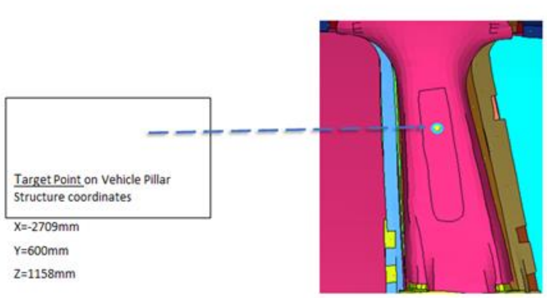

Figure 03

The FMH is made positioned against the Vehicle B Pillar A-Surface using USNCAP FMVSS201U Regulation.

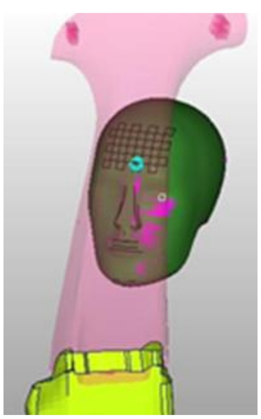

Figure 04

Hit On Head HOH at Primary Touch with the Pillar, Height=16mm Side=5mm

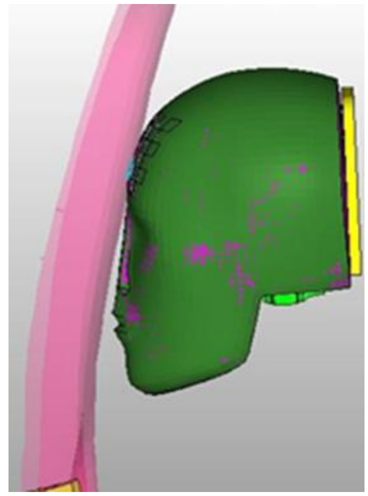

Figure 05

Hit On Head HOH at Shooting Position Shooting Position with the Pillar Height=21mm Side=5mm

Dyna Deck

LS-DYNA is a general-purpose finite element program capable of simulating complex real-world problems.

Full Vehicle is de-contented & trimmed based on required portion of the vehicle to reduce the CPU time.

Figure 06

- Current B Pillar structure is not meeting the Regulation with respect to Head loading & Head injury requirement.

- Iterating the vehicle pillar structure with Energy Absorbers like Honeycomb & Cross ribbing structure or Crash Foam
- Review includes Dummy Loading, Crash Energies, Energies balance, Head Injury, Reaction forces.

FMVSS 201U Procedure and Requirements

- Target the vehicle
- Establish vertical and horizontal angles (defined in CFR) for impact
- Select targets likely to be worst-case (based on engineering judgment)
- Evaluate targets for airbag proximity: „ Standard impacts conducted at V = 24 kmph Impacts near airbags conducted at V = 19 kmph
- Conduct test and analyze data

Requirements of FMVSS 201U "The HIC(d) shall not exceed 1000"

- HIC = Head Injury Criteria
- Unit-less value which represents injury severity of the head
- HIC(d) = Head Injury Criteria for an Anthropomorphic Test Dummy (ATD)
- Relates the FMH back to a full ATD

III. RESULTS AND DISCUSSION

Baseline model

In the base line model, no ribs are considered.

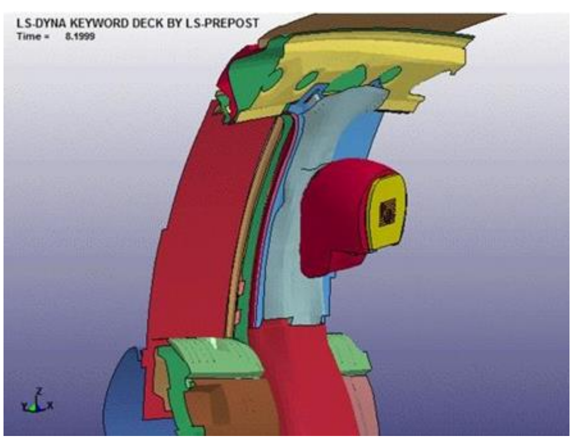

Figure 07

Simulation Energies Balance

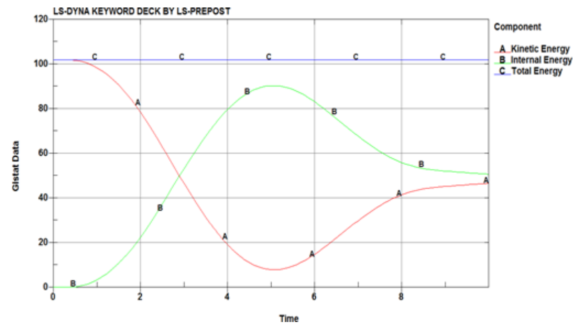

Figure 08

Observation:

- Glstat (Joule) Vs Time (ms) is plotted.
- Global energies said to be balance as the Kinetic energy is the mirror image of Internal energy.

Simulation Part Energies

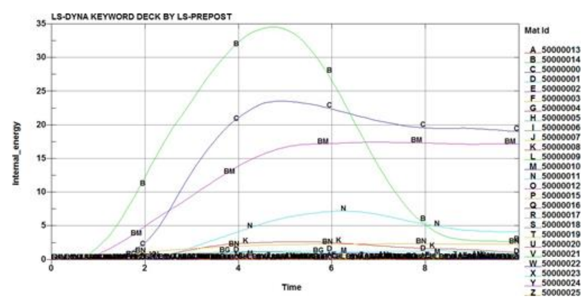

Figure 09

Observation:

Internal Energy (Joule) Vs Time (ms) is plotted.

Maximum crash energy observed in Part ID's --- 50000014 (B) , 50000000 (C) & 6 (BM)

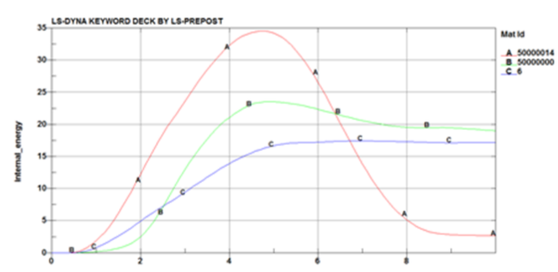

Figure 10

B pillar absorbing the Energy 50000014 = 35 Joule

Vehicle sheet metal absorbing the Energy 50000000 = 24 Joule
Dummy Skull observing the energy is 6= 17 Joule

FMH Injury

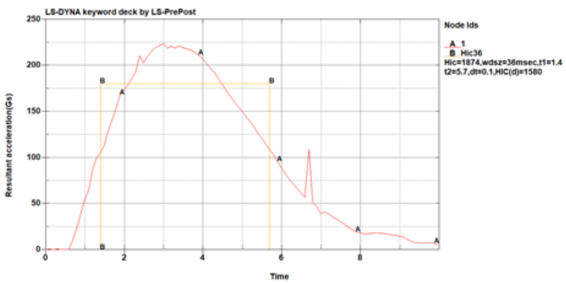

Figure 11

Observation:
Acceleration (mm/ms2) Vs Time (ms) is plotted.
Head Injury Criteria for Dummy (HIC (d)) is recorded at the CG of the FMH is 1580.

Baseline Conclusion

- Global Energies of the trimmed B pillar Structure is Balance
- Trim with BIW component along with Dummy Skull is absorbing the maximum crash energy during simulation
- HIC(d) = 1580, which far more than the USNACP injury limiting value of 1000
- Current B pillar doesn't meet the NHTSA performance requirement
- Next task is to optimize the B Pillar by using different energy absorbers

Iteration to reduce the Head Injury less than 1000 (NHTSA US NCAP)

Rib is added as energy observer to reduce the HIC value below 1000

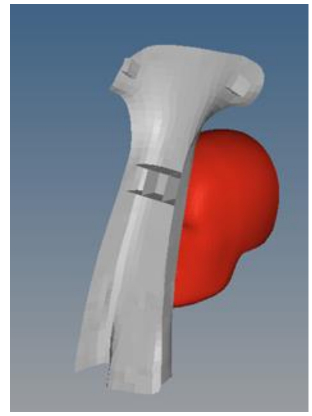

Figure 12

B Pillar Ribbing Structure

Simulation Energies Balance

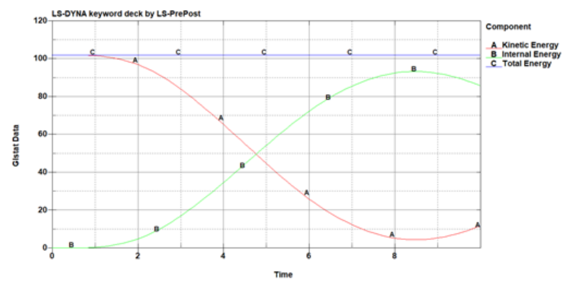

Figure 13

Observation:
- Glstat (Joule) Vs Time (ms) is plotted.
- Global energies said to be balance as the Kinetic energy is the mirror image of Internal energy

Simulation Part Energies

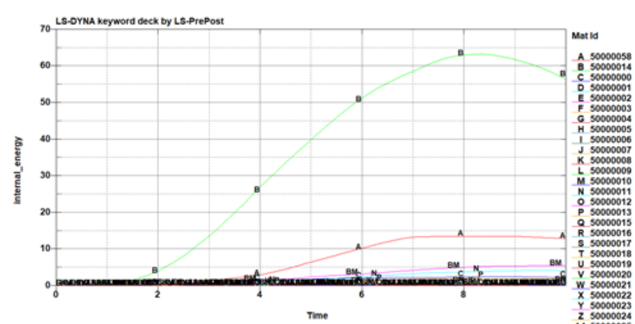

Figure 14

Observation:
- Internal Energy (Joule) Vs Time (ms) is plotted.

- Maximum crash energy observed in Part ID's --- 50000014 (B), 50000058 (A) & 6 (BM)

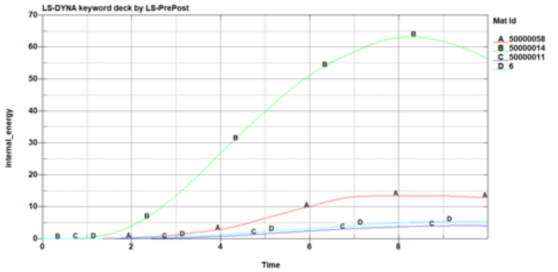

Figure 15

FMH (PID 6)= 6 Joule
Ribbing (PID 50000058) = 14 Joule
B Pillar(PID 50000014)=63 Joule
Vehicle sheetmetal absorbing the Energy 50000000 = 4 Joule

FMH Injury at B Pillar Target Point

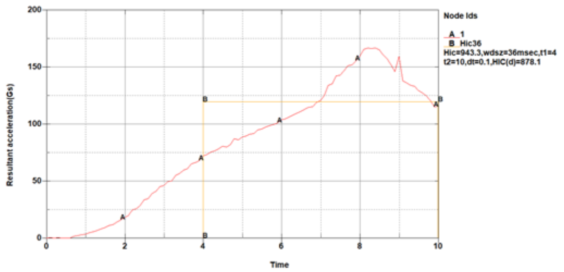

Figure 16

Observation:

- Acceleration (mm/ms2) Vs Time (ms) is plotted.
- Head Injury Criteria for Dummy (HIC (d)) is recorded at the CG of the FMH is 878.1.

CONCLUSION

- Current baseline simulation of the B pillar of Ford Taurus vehicle doesn't meet the NHTSA performance requirement
- Baseline simulation - HIC(d) = 1580, which far more than the USNACP injury limiting value of 1000
- Iterations were carried with ribbing Energy Absorbers using different tooling patterns
- Iterations No 1 result in Hic (d) = 878.1 < 1000
- In Iter No 1, Effective crash energy absorption notice in the B pillar trim along with ribbing structure

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